MODELING THE OPERATION PROCESSES IN FOOD MANUFACTURING BY USING SIMULATION TECHNIQUE

SICK KIM CHEN (PC11005)

Thesis submitted in fulfillment of the requirements for the award of the Bachelor of Industrial Technology Management with Hons

Faculty of Industrial Management
UNIVERSITY MALAYSIA PAHANG

DECEMBER 2014

ABSTRACT

This study discusses about modeling the operation processes in food manufacturing by using simulation technique. The scope of this study is to focus on the production processes of chili sauce's company. The time frame covered is one year which is in year 2014. This study is conducted by using ARENA simulation software to simulate the modeled of chili sauce production processes in the simulation software. It is a quantitative study which the performance of the processes is measured by the average cycle time for the whole system of chili sauce processes. The results of the simulation model of the chili sauce processes has determined the bottleneck in the process and measured output of the process. The improvement has been made by using "What-if Analysis" and scenario planning approach.

Keywords: Simulation, ARENA Software, Cycle Time, Average Queue Waiting Time, Utilization, and Bottleneck.

ABSTRAK

Kajian ini membincangkan tentang model proses operasi di kilang makanan dengan menggunakan teknik simulasi. Skop kajian ini menekankan pada operasi pemprosesan di kilang sos cili. Tempoh masa untuk kajian tersebut diliputi adalah setahun iaitu pada tahun 2014. Kajian ini juga dilaksanakan dengan menggunakan perisian simulasi ARENA dengan menghasilkan model mengikut proses pemprosesan sos cili di dalam perisian simulasi. Jenis kajian ini merupakan kajian kuantitatif dimana prestasi pemprosesan sos cili diukur dengan purata masa kitaran untuk keseluruhan proses tersebut. Keputusan daripada perisian simulasi dapat mengesan kesesakan dalam proses berkenaan dan juga bilangan pengeluaran dapat diketahui. Peninkatan prestasi pada proses tersebut dapat dilaksanakan dengan mengunakan kaedah "Apa-jika" dan kaedah senario.

Kata Kunci: Simulasi, Perisian ARENA, Kitaran Masa, Purata Masa Menuggu, Penggunaan Sumber, dan Kesesakan.

TABLE CONTENT

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This research study is to evaluate and analyze the chili sauce production processes from the Chili Sauce Manufacturing in Padang Tembak, Pengkalan Chepa, Kelantan. The evaluation on the production processes is to determine the organizational performance. The purpose of analyzing the process system is to improve the quality of the process to become more efficient and increase the quantity of the product to support the market demand by using simulation technique which is practiced well in manufacturing and service sector. This chapter will cover the background of study, problem background, problem statement, research objective, research question, method of analysis, scope of study, significance of study, operational definitions, and conclusion of this chapter.

1.1 BACKGROUND OF STUDY

Chili Sauce Production Manufacturing was registered under the Small and Medium Enterprise (SMEs) in Malaysia. SMEs in Malaysia has contributed to Malaysia growth development per capital (GDP) in our country. The growing of SMEs in Malaysia's GDP is about 32% in 2013, considering its current growth momentum and the country's healthy economy. According to the (SMEs MASTERPLAN 2012 – 2020), service sector has contributed 87% to our country's economy, which is the highest while manufacture sector and agriculture sector has contributed 7% and 6% respectively. In term of size in SMEs Corporation, microenterprise with less than 5 employees is the higher or 67%.

Nowadays, our government also encourages all people to involve in business whether in service sector, manufacture sector or agriculture sector to keep ongoing contribution in order to increase the Malaysia's economy. According to the Tenth Malaysia Plan (10MP), the development of SMEs will be given more focus and it may become the vibrant engine of Malaysian economy growth. During the Tenth Malaysia Plan period, Malaysia government will conduct a lot of program and support to nurture SMEs in order to create "domestic, regional, and global champions". In order to increase the performance and reputation of SMEs, they may use the simulation techniques to evaluate, create a model, identify the problem, and etc. By using the simulation techniques, they can forecast the future demand of their business.

Operation management is very important in industrial and manufacturing sector because it will manage all the processes or stages in the production. Operation management can be explained as a set of activities or steps that create value in the form of goods and services by transforming the input into outputs. The examples of the inputs are raw materials such as labors, machine, equipment, and etc. The examples of output are finished goods, semi-finished goods, and also work-in-progress (WIP). An excellent of operation management in the production system will increase the organization's profitability and reputation. Process design in operation management is to combine all the aspects of an industry or organization with the needs and requirement from the customers.

Capacity planning is an activity or process that determines the production capacity of the product needed by the company to meet customers' needs and requirements or the changing of demands for its product. Capacity planning can be categorized into three time horizon of planning which are long-range planning, intermediate-range planning (Aggregate planning), and short-range planning (Scheduling). The time period for long-range planning is normally greater than 1 year. This stage of planning includes the adding of the facilities and equipments in the organization that need a long lead time. Besides, the time period for intermediate-range planning and short-range planning are 3 to 18 months and lower to 3 months respectively. Intermediate-range planning is to plan and make a decision either want to add the equipment, personnel, and shifts; subcontract the production of product to the

third party; and we can store and use the inventories in the warehouse when needed. For the short-range planning, scheduling the jobs and people, as well as allocating the machinery is enhanced. To change and modify capacity in the short-range planning is difficult to be implemented as it is constrained by existing capacity.

The role of bottleneck or constraints is a key concept that related to the capacity planning. Bottleneck problem in an operation process limits the production process flow. The bottleneck problems will decrease the efficiency of the production process and it will limit the output or finished good. The word bottleneck is referring to the neck of the bottle, which is water inside in the bottle can flow out based on the diameter of the literal neck of the bottle. There are three metrics to analyze production capacity system which is process time of a station, process time of a system, and process cycle time. Process time of a station is the time to produce the product in each process. Process time of a system is the longest process of bottleneck. Process cycle time is the time for overall production process with no waiting time.

1.2 PROBLEM BACKGROUND

There are many food manufacturing that produce chili sauce in Kelantan and high competition has been occurred. In this kind of situation, negative effect is given especially to small manufacture because small manufacture cannot supply the product in the high quantity to meet the customer demand. Small food manufacturing cannot provide the lower prize for customer because the quantity of the product is too low compared to the large manufacture.

The competitions in the market occur in the daily life especially for the food manufacturing because there are a lot of people involving in this field of business. Many people involving in food field of business because many people believe that human need food for their living and also human enjoy their life with the delicious food. Although there are high demand on food in the market, but still have some manufacturing cannot be survive in a strong competition especially for small manufacturing.

Based on this research, Chili Sauce Manufacturing in Padang Tembak, Pengkalan Chepa, Kelantan is hard to survive in the market because they cannot to provide a capacity of the product that meet the customer demand. The break even cost of the manufacturing is also higher than the other huge manufacturing. This challenge need to be reduced by increasing the efficiency of the production process and eliminate all the constraint such as bottleneck. Furthermore, some of the processes are operated manually which longer time is needed.

1.3 PROBLEM STATEMENT

Production process is a process that transforms the input or raw material into the output or finished goods. In production process system, there are a lot of problems and constraint such as machine failure, lack of raw material at peak season, and etc which cannot be avoided. Although these problems cannot be prevented, they can be reduced.

According to the chili sauce manufacturing, bottleneck is the constraint that occurred in the production process. Bottleneck in the production process will limit the production process system. This limit will cause the production capacity decreasing and the production process needs a long cycle time to produce the product.

Chili sauce demand in the market is flexible. The customer order will increase at the peak season and decrease otherwise. The capacity of the product will not be able to support the customer demand especially at the peak season. So, chili sauce manufacturing needs to reduce the constraint such as bottleneck in the process system because it will reduce the cycle time of the production. Automatically the capacity of the product will be increased.

Without the bottleneck constraint in the production process system, it will help the company reduce cost and increase the organization profit. The cycle time of the process also will be shorter than before and increase the capacity of the product.

1.4 RESEARCH OBJECTIVES

The objectives of this research are:

- ✓ To identify the bottleneck of chili sauce production.
- ✓ To measure a capacity of chili sauce production at the plant under study.
- ✓ To propose an improvement of chili sauce production process.

1.5 RESEARCH QUESTIONS

The questions of this research are:

- ✓ Where is the bottleneck constraint that occurred in chili sauce production process?
- ✓ How many capacity of chili sauce production can be produced?
- ✓ What is the improvement on the chili sauce production process?

1.6 METHOD OF ANALYSIS

Method, tool, or technique is the important elements to conduct a research study. According to this research study, the most appropriate method to evaluate and analyze this research is by using the simulation techniques and data collection method. Simulation techniques are a well known method and it was practiced in many countries to detect any constraint in the production system. Normally it will be used by manufacturing to solve the constraint in the production system such as bottleneck. Arena software will be used to apply simulation technique in this research. It can analyze the production system and detect the problem that occurred in the process. Moreover, simulation techniques no need to use very high cost and the result of the analysis is easier to get. Furthermore the risk of failure can be reduced by using simulation because there is no need to use the real situation to analyze the production system.

Data collection method is also important because it can support the simulation technique to analyze and evaluate the process. Real data is needed to create the production system model using Arena software to represent the real production system.

The data and information must be accurate. So, the better technique to collect the information and data is by using observation method which is called as primary data. Secondary data also needed to support the primary data such as historical data and interview method.

The improvement of the chili sauce production processes can be determined by using "What-if Analysis" approach and also scenario analysis. "What-if Analysis" approach is a changes on the processes in the simulation model and analyze the simulation model the get the better results. Meanwhile, scenario analysis is a technique that to analyze the possible future events by considering alternative possible outcomes from "What-if Analysis" approaches and also its management in the company.

1.7 SCOPE OF STUDY

This research will focus on evaluating the performance of the Small and Medium Enterprise (SMEs) food manufacturing, in Padang Tembak, Pengkalan Chepa, Kelantan. This organization produces the tomato and chili sauce. In this research, I will focus on the capacity planning and bottleneck on chili sauce production process. The good planning on the process will give a good result in term of profitability to the organization. From this research results, it may give a new idea and system to the organization to implement the new model of production system.

At the beginning of the research, I will create a model based on the actual production process of chili sauce manufacturing by using the Arena software. From the model, I will run the model to get the result. From the result, the evaluation of the chili sauce production can be determined. The evaluation of the performance based on the actual production process will be a benchmark to the other model that will develop it to increase the performance. The development of the model or redesign the production process will be implementing by using "What-if" analysis approach to get a better production process system compared to the original production process system. It will reduce a lot of cost by using this approach.

Producing chili sauce has several stages and steps of process which are including the machine and handmade or manually process without using the machines.

There are bottleneck problem on the some stage of production process in the organization to produce the chili sauce. After figuring out the bottleneck stage on the production process, we need to reduce the waiting time of the bottleneck problem in the related station or stage. This includes reducing the overall time of chili course production. So it may increase the capacity or quantity of the product and meet the customers demand in market.

As a conclusion, the best of new model in the production process to produce chili sauce will be proposed to the organization. The best model should be meet the objective of the research which is the model has a high performance compared to the current model and the waiting time in the bottleneck station has been reduced. So this model will allow the company to produce the chili sauce according to the customers' orders and will meet the customer needs in the market. This also will automatically increase the organization reputation and efficiency.

1.8 SIGNIFICANCE OF STUDY

The production process in the manufacturing is vital because without a good operation process management, the company performance and reputation will decrease. This research is to overcome the problem such as bottleneck in each station or stages in operation process. This automatically will reduce the overall processing time to produce the chili sauce. When the processing time reduces, the capacity and quantity per day will increase. Hence it will meet the customer demand in market.

This research can be a guideline to all manufacturing which has operation and production process to produce a product. This research result also can be used for any food industry sector as well as the agriculture and service sector. This will provide the strategy to the company on how to develop a better process design to overcome several problems such as high demands and low supply in the market, bottleneck problem in each station or stage, and lack of labors or workers. This finding is important to help the company to run the process going smoothly without any problems and errors.

This study also important to the owner's of the company, managers, workers, and also supplier. Managers need to plan everything that related to the operation process that may affect the operation process. Nowadays, there are a lot of machines and techniques are upgraded to be more efficient. So they need to study the new method or research to understand more about the current problem that the others company face and see how they solve the problem by using certain technique, method, and tools.

1.9 OPERATIONAL DEFINITION

Based on to the research, there are several key terms have been used in this research study. For examples of key terms are chili sauce, operation management, capacity planning, bottleneck, theory of constraint, and also simulation technique. The definitions of all the key terms are:

Chili sauce:

According to the (Darlene Schmidt), chili sauce is an extraordinary seasoning that adds spice and flavor to the all types of dishes. Chili sauce basically is an Asian recipe and now was spread to the western favorites. It also can be used as a wonderful dip for fingers for all types of food. Besides, it also can be used as a condiment to add more spice to your food. Moreover, chili sauce is a handy cooking ingredient. Using chili sauce as a food and dishes condiment is very famous in the Asian country as well as in Mexico and Central America. If there are no a bottle of chili sauce can considered the table setting is not complete.

Operation management:

The definition of operation procedure refers to the process of operating something or dealing with a particular situation, procedure, or processes. The term operational defines something such as a variable in term of precise process or set of validation experiments that are used to establish its present and quantity.

Capacity planning:

The definition of capacity planning is the process of finding the production capacity that needed by the company to meet the fluctuated demands for its product to meet the customer satisfaction. There are two categories in the context of capacity planning which is design capacity and effective capacity.

Bottleneck in Production Process:

Bottleneck in an operation management defined as a problem occurred when all the activity has a limit in a certain stages or station to ongoing the throughput. The word of bottleneck is based on the "assets are water" metaphor, which means when the water is poured out from the bottle, the rate outflow is limited by the width of the conduit exit.

Theory of Constraint:

According to the Sergio Rattner, the Theory of Constraint (TOC) is an organizational change method. It focused on the improvement of profitability in the organization. Based on the TOC, every organization must have at least one constraint. The constraint is any factor that limits the organization to achieve its goal and increase the profit. In manufacturing, the constraint is called bottleneck.

Simulation technique:

According to the investopedia (Monte Carlo Simulation), the definition of simulation is a problem solving technique that can be used to approximate the probability of certain output or results by using the multiple trial runs, or using random variables。

What-if Analysis approach:

The definition of "What-if Analysis" approach is the measure of the changes on the independent variables which can impact the dependent variables as the output and result with reference to a given simulation models.

Scenario planning:

Scenario planning also known as scenario analysis and scenario thinking which means the future event planning or long term planning process that was generate by using simulation methods.

1.10 CONCLUSION

The bottom line of this chapter is the production process system is a very crucial thing that needs to be planned by all the company's owner or managers. This is because the failure of planning in production process will affect the company productivity, profitability, and reputation. To support the production process is runs smoothly, the good planning on the capacity planning is needed because this also include in the operation process to produce the product. When the lack of input such as raw materials is occurred, the process also needs to stop. The bottleneck problem in any station also will disturb the production process because there are long waiting time. To overcome to these problems, simulation technique is the most suitable approach to be used because simulation technique can create a model of operational process. When model is created, we can see the results or performance of the model without using the real process. This may reduce the company cost and time to get the results before setup or redesign the real production process system. Simulations technique will be used in the Arena software.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The meaning of literature is writing and a body of literature is refers to all the published writings in a particular style on a particular subject. Literature review means a study on the literature that has been published by the scholars and researcher. Basically the types of literature review include journal, articles, book, authoritative database, and primary source. Newspaper, magazines, film, audio, video, and secondary data are included in the literature review but it is seldom used by the researcher. The primary source is original information or firsthand literature that used by the research to refer and support the research as the evidence. The literature review will be divided into several subtopics which include food processing in industry, operation management, simulation study, product capacity, bottleneck in each process, constraints in operation process, and theory of constraints.

2.2 FOOD PROCESSING IN INDUSTRY

Malaysia food processing manufacturing has become a crucial segment of the agro-based industry according to the government's focus on the agriculture sector. Based on the Industrial Malaysian Plan 2006-2020 (IMP3) period, the target for the food processing industry have been set at RM24.6 billion (Ministry of International Trade and Industry, 2012). In the area of the business environment, manufacturing from Small and Medium Enterprise (SMEs) was dominated the food industry in Malaysia. Functional food, health food, convenience food, food ingredients, and halal

food are the growth food in the year of 2002. Business growth can be explained as the growing in an organizational capital or expansion of its size and capability. Growth is a very important component to all organization especially in business because it will measure the organizational performance whether it is in good reputation or vice versa (Kartinah and Rabaah , 2013).

2.3 OPERATION MANAGEMENT

Operation management was practiced everywhere in the world whether in manufacturing, and service industry. Operation management is related to the production process. Production means the creation of goods and services in the firm. Production plays a high role in the operation management which is a set of activities to have a throughput and transform input into the output to create value in the form of goods and services in the organization. All the organization will do this activity to have a better planning, increase productivity, increase profit and others that give a benefit to the organization. Production in manufacturing industry is an activity to create tangible goods which customer can see and touch it such as food, car, motorcycle, and etc. Otherwise, the organization that does not produce tangible product is called activities services. The service is not obvious and hidden from the public and even from the customer. Operation management is crucial because it is a costly part of an organization (Jay and Barry, 2011).

2.4 CAPACITY PLANNING OF PRODUCT

Capacity requirement planning is one of the planning methods and it can calculate and measure the ability in the operation process. Capacity is the quantity of the product and it is related to the production demand. A good capacity planning can make sure there is enough production capacity to meet the production demands. Production demands basically will depend on the customer needs and orders. After that, it also can be used to analyze and check the feasibility of production plan outline, main production planning, and material requirement planning. Furthermore, it can change the production demand into relevant capacity requirement and estimate useable capacity. Besides, it can make relevant calculation to balance the production capacity and production load.

MRPII/ERP system can detect the bottleneck in the production process by the capacity requirement planning (Yang et al., 2007).

Capacity discrepancy between mid-term capacity planning and consistently delivering promised capacity can be eliminated by the efficient system of modeling. Conflicting objectives in capacity planning and production scheduling can be resolved. It will be resolved by the capacity constraints that derived from production rate, machine timeline, and machine allocating preference matrix. Otherwise, the configurable constraint are designed and implemented for special concerns in planning and scheduling functions. It also will facilitate the pursuing of optimized production plans and schedules. The collaboration between two or more company is very important. They also can share the data among collaboration companies to forecast, order, and production status for continual enhancement of the deliverability and gaining more market shares. Sharing information between mid-term and short-term production capacity among companies will improve customer service level, reduce cost through the synchronization of resources, analyze and adjust the capacity arrangement timely, and response swiftly to changes in market (Wang et al., 2005).

Nowadays, the key factor to maintain invincible in the high competition market of enterprises are quick response specific to market changes and needs along with the horizontal and vertical development of economic globalization trend and growing diversification of customer demands. To improve the efficiency of enterprise operation and utilize various internal and external resources held by the enterprise as far as possible, enterprise need to apply the modern computer and network techniques to transform traditional enterprise operating method. For example, realizing the enterprise information by making use of the ERP system. Moreover, to manage the enterprise operation, the information technology is adopted. (Tu et al., 2011).

Saving the investment cost by producing an optimal long-term facilities planning of the mould enterprise is a very crucial thing because the facilities is very expensive. To balance the manufacturing production capacity and demand is the key decision of the long term of capacity planning. There are different characters to the flow shop manufacturing. First of all, mould manufacturing is under the condition of single

unit job lot production. The buffer between the capacity of facilities and production demands because there is no mould inventory. The similar type facilities were put together and shared the process kinds of parts many mould orders in the same time to enhance the utilization ratio of facilities. There are replaceable multi-process routings to produce one type of mould part with the improvement of technology. The process time and manufacturing cost of these routings are different (Yu and Chen, 2011).

Thin Film Transistor Liquid Crystal Display (TFT-LCD) is a Taiwan company and the production networks of this company have three manufacturing stations. The manufacturing stations or stages are called as Array, Module, and Cell processes and each station has multiple production sites. Array and Cell processes are capacity-constraint and high- investment production environment. Utilization and planning for the production capacity effectively is a very important to the TFT-LCD company. The TFT-LCD has paid the attention to the capacity planning has become problem as a very crucial thing because of the several reasons. The first reason is the complex product hierarchy and product types caused by a wide range of product application (Karabuk and Wu, 2003). The second reason is a multi-stage, multi-generation and multi-site production network generated by coexistence of multiple generations of manufacturing technologies in each manufacturing stage and production site (Swaminathan, 2000). The last reason is the rapid growing and changing market demand due to the consumer requirements for the replacement of the traditional Cathode Ray Tube (Wang and Lin, 2002). TFT-LCD Company is facing the critical strategic capacity planning problem due to the rapid-changing product-mix. This problem is due to the imbalance demand and supply in multi-generation and multi-site productions chain (James*et al.*, 2009).

2.5 BOTTLENECK IN PRODUCTION PROCESS

Operation process for producing product is a crucial thing in manufacturing and minimizing the cost, having a competitive business, and managing the operation process efficiently in manufacturing are not an easy role for manager and top management to implement. There will be a new problem or old problem will reoccur in the period of time although the processes have been done with prevention and appraisal of the problem. All these problems that are constraints of business utilizing various resources

in different forms without adding any value in the system called bottleneck in manufacturing unit. Bottleneck also can be derived as an activity which delays the performance of the process and reduce the overall efficiency of the process. For example company has many process lines of production and each of them are connected to each other. The process cannot support the quantity of previous process if one of the machines is broken. Delay of production will occur and it will affect the output of the production.

The main reason of the production lines in a manufacturing unit slowing down is because of the bottleneck problem. Bottleneck in production lines need to be identified, analyzed, and to be resolved on the basis of facts. When bottleneck in production lines is identified correctly and efficiently, it can help to reduce the production cost and increase overall efficiency of the process. There can be a long term or short term constraints in the process in manufacturing. Fishbone diagram is one of the approaches that can identify the bottleneck in operation process. Fishbone diagram also can be called as Ishikawa diagram or cause effect diagram and it was created by Dr. Kaoru Ishikawa from Japan. Fishbone diagram is a quality control tool that provides a systematic and graphic way of identifying possible causes for a problem by using categories to focus and structure the thinking in order to work toward determining the root causes (John, 2012). According to this approach, different data related to the problem are collected and analyzed precisely in order to determine the root cause for the particular problem (Peter, 2010).

There is one research on finding a new method to determine the bottlenecks and rank the bottlenecks level in a manufacturing system. To analyze and determine bottlenecks in a production process is not an easy task to accomplish. Bottleneck problem in production line usually come from the Optimum Production Technology, or known as "Theory of Constraints". Besides, the main problem of the bottlenecks are caused by the manufacturing line are inherently variable. The cause of this variation might be due to random events or machine failure and long term changes in the system such as seasonal variation of demand, new product launch, and machine load changes. Bottleneck in the production line can be categorized into two which are dominant bottleneck and momentary bottleneck. Dominant bottleneck is a fixed or most occurred